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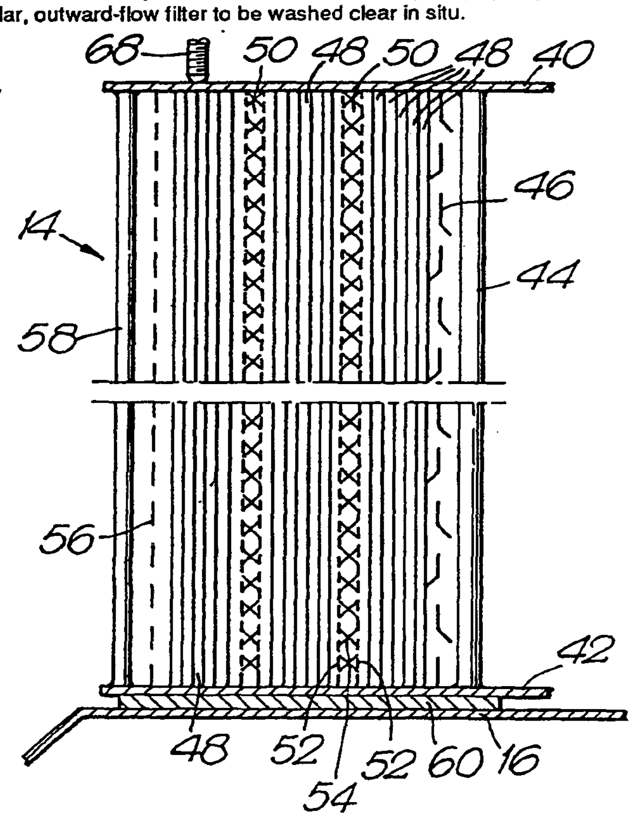
(54) A filter

(57) A filter (14) for removing liquid droplet, or solid particle, aerosols from a gas stream includes layers (48) of a high voidage fibrous material with fibre diameters typically 4 microns, and drainage channels (50) for liquid between successive fibrous layers. The filter (14) may be formed entirely of stainless steel, or the layers (48) may comprise glass fibres. In Fig.1 a central spray nozzle allows a tubular, outward-flow filter to be washed clear in situ.

Fig.2.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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Fig.1.

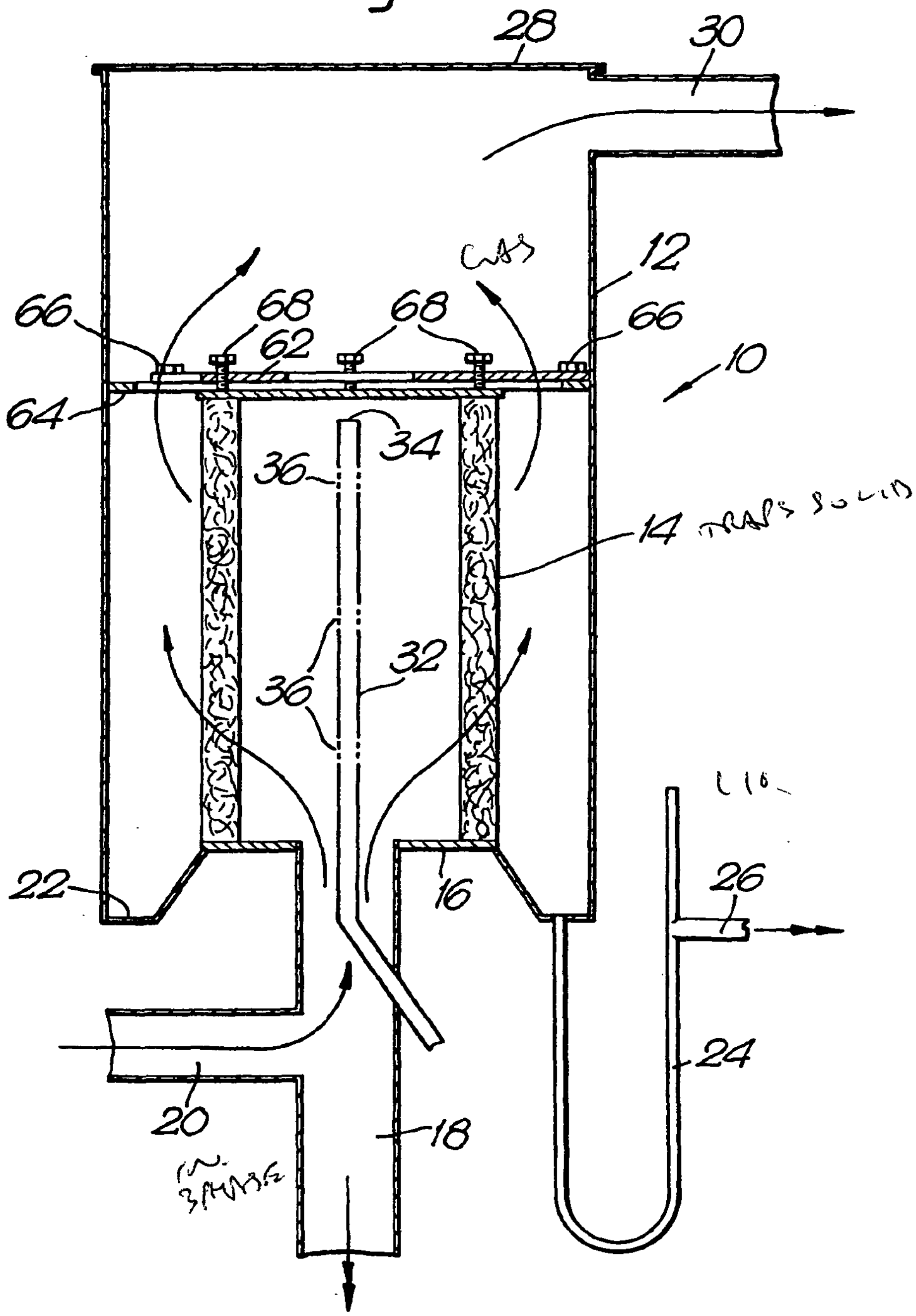


Fig.2.

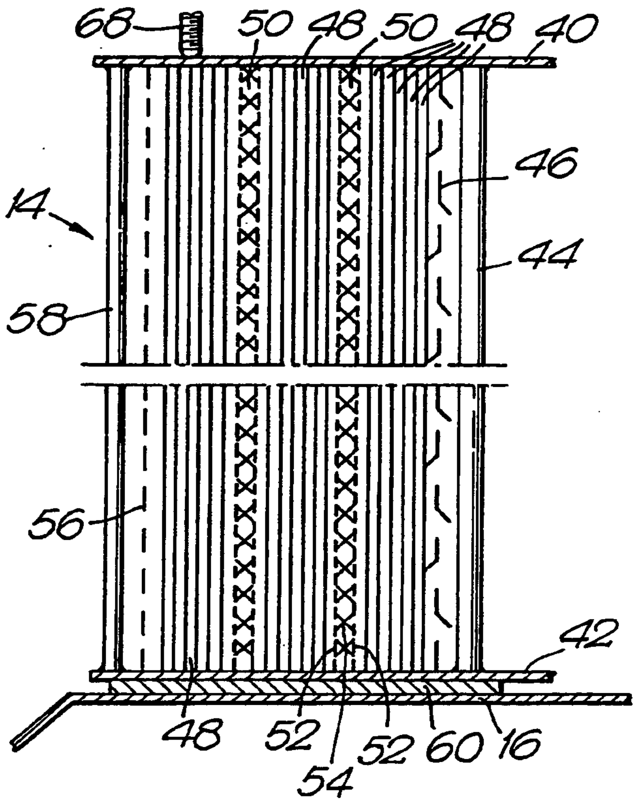
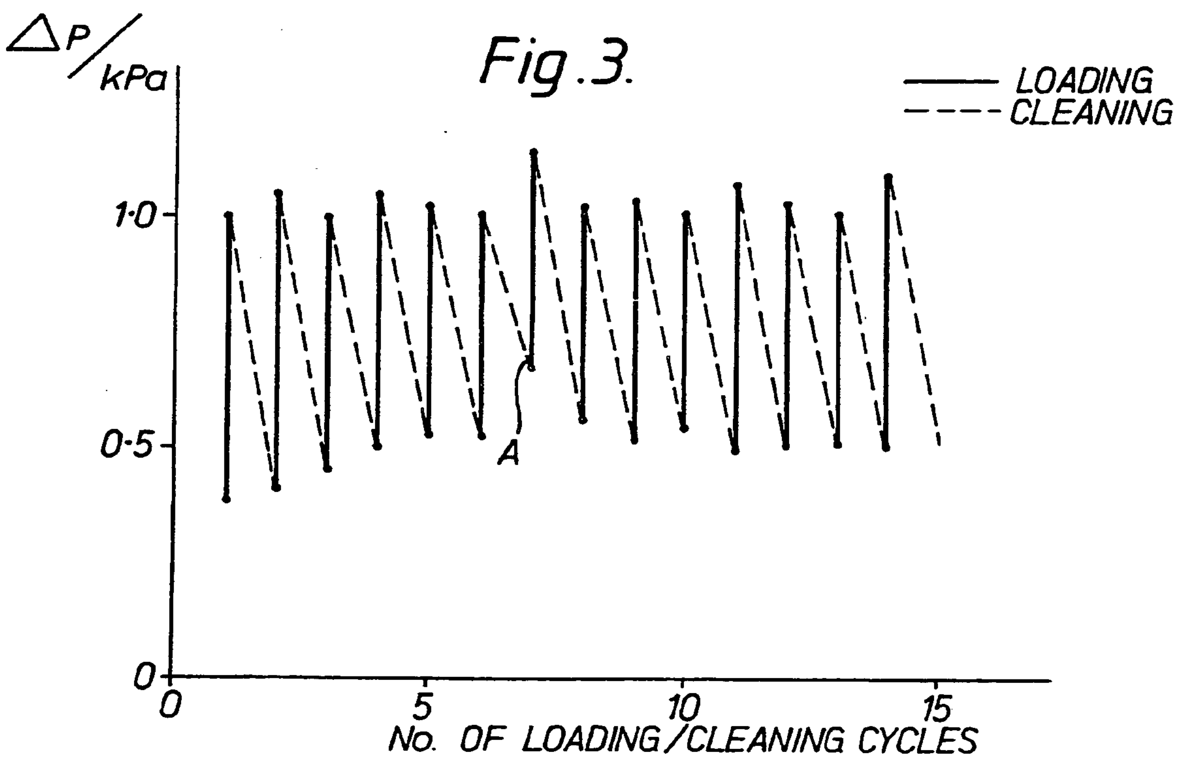

68
50
48
50
48
40
46
14
44
58
56
42
48
52
54
52
60
16

Fig.3.


ΔP/kPa
LOADING
CLEANING
1·0
0·5
0
A
0
5
10
15
No. OF LOADING/CLEANING CYCLES

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A Filter

This invention relates to a filter suitable for removing small dust or mist aerosols from an air stream.

The removal of liquid droplets and solid aerosol particles no larger than a few micrometres in diameter from gas streams in plants in which radioactive materials are processed is advantageous, as it minimises the amount of radioactivity deposited on high-efficiency particulate in air (HEPA) filters through which such gas streams are subsequently passed. Such particle removal may be performed using electrostatic precipitators, but these have a high capital cost, and their operation is not passive in that they cease operating in the event of a power failure.

According to the present invention there is provided a filter for a gas stream comprising a plurality of layers of high voidage fibrous material whose fibres are of diameter less than 10 micrometres, and incorporating drainage channels defined between successive fibrous layers.

By high voidage is meant that the voidage exceeds 90%, preferably exceeding 95%. Such a filter may produce only a small pressure drop (say 1 kPa) while producing a decontamination factor of between 200 and 1000 for particles in the size range 0.5 to 3 micrometres, the decontamination factor being the ratio of the numbers of aerosol particles per unit volume before and after passage through the filter. Because of the drainage channels, liquid bubbling from the rear face of the filter with consequential re-entrainment of contamination is eliminated. Furthermore the filter may be washed by spraying it with water to remove deposited solids, and this may be performed in situ even with the filter in use.

The drainage channels may be defined by a layer of a

coarse mesh interposed between successive fibrous layers. The filter is desirably of tubular shape with the gas flowing radially through it. Preferably the fibrous material is stainless steel, and the fibres are preferably of diameter about 4 micrometres.

The invention will now be further described by way of example only and with reference to the accompanying drawings.

Figure 1 shows a diagrammatic longitudinal sectional view of a filtration unit incorporating a filter of the invention;

Figure 2 shows in more detail and to a larger scale part of the filtration unit of Figure 1; and

Figure 3 shows graphically pressure drop variations during operation of the filtration unit of Figure 1.

Referring to Figure 1 a filtration unit 10 is shown for removing sub-micron liquid droplets and solid aerosols from a gas stream; the unit 10 comprises an upright cylindrical housing 12 in which is a tubular cylindrical candle filter 14 closed at its upper end, standing on a raised central portion 16 of the base of the housing 12. A duct 18 extends downwardly from the centre of this central portion 16, and has a side duct 20. Around the central portion 16 of the base of the housing 12 is a liquid drainage gutter 22 communicating via an open-ended U-tube 24 with an outlet tube 26. The top of the housing 12 is defined by a lid 28, and near the top is an outlet duct 30. A tube 32 of diameter 20 mm extends upwardly through the wall of the duct 18 and inside the candle filter 14, almost

reaching the top of the filter 14. Its top end 34 is closed, while the portion within the filter 14 incorporates twelve spray nozzles 36 (shown diagrammatically).

In operation of the unit 10, a gas stream laden with solid particles and/or liquid droplets as an aerosol is passed in through the side duct 20, and flows up the duct 18 into the middle of the candle filter 14. The gas then flows radially outwards through the filter medium; then upwardly through the housing 12 to emerge through the outlet duct 30. The gas flow is indicated by single-headed arrows. Any liquid droplets in the gas stream are caught by the filter medium, and drain down either back down the duct 18, or into the gutter 22 and out of the U-tube 24 and outlet tube 26 (indicated by double-headed arrows). Solid particles remain trapped in the filter 14.

Referring now to Figure 2, which shows in more detail one side of the candle filter 14, the filter 14 includes a circular stainless steel top plate 40 and an annular stainless steel bottom plate 42 of the same external diameter, the plates 40 and 42 being joined to each other by six equally spaced stainless steel inner tie rods 44, (only one of which is shown) welded to the plates 40 and 42. Adjacent to the tie rods 44 and defining the inner surface of the filter medium is an expanded stainless steel support sheet 46 spot-welded to the plates 40 and 42. Next are five layers 48 of stainless steel fibrous filter material, with fibres of diameter 4 micrometres, each of areal density 285 g m^{-2} and of thickness 2.5 mm. Outside these layers 48 are drainage channels 50 defined by three layers of stainless steel mesh: first a layer 52 of fine mesh (0.6 mm square hole), then a layer 54 of coarse mesh (8 mm square hole), then another layer 52 of the fine mesh. There are then another five layers 48 of the same stainless steel fibrous filter material; then another drainage

channel layer 50 defined by the same stainless steel meshes; and then another five layers 48 of the same stainless steel fibrous material. The outer surface of the filter medium is defined by an expanded stainless steel grille 56 spot welded to the plates 40 and 42. Outside the grille 56 the plates 40 and 42 are joined to each other by eight equally spaced outer tie rods 58 (only one is shown) welded to the plates 40 and 42.

Before assembly of the candle filter 14, each layer 48 is preshunk by washing with water and allowing to dry, at least three times. This causes the fibres to move slightly closer together so each layer becomes thinner. Each layer 48 is cut to be about 10 mm wider than the distance between the plates 40 and 42, which ensures no leakage occurs around the top or bottom edges of the filter medium in operation. The dimensions of the candle filter 14 are: internal diameter 350 mm, thickness of filter medium 50 mm, length 710 mm.

Referring again to Figure 1, the candle filter 14 is inserted into the housing 12 through the lid 28; between the bottom plate 42 of the filter 14 and the central portion 16 of the base of the housing 12 is an annular rubber gasket 60 (see Figure 2). The filter 14 is held in position and the gasket 60 compressed by a spider 62 whose legs are secured to a flange 64 on the inner wall of the housing 12 just above the top of the filter 14 by bolts 66 (only two are shown); bolts 68 (only three are shown) extend through threaded holes through the spider 62 to exert a downward force on the top plate 40 of the filter 14.

The candle filter 14 does not generate a large pressure drop in operation; the pressure drop is proportional to the gas flow rate, but for example at a

face velocity of 0.4 m s^{-1} the pressure drop is only 1.4 kPa (140 mm water). Nevertheless it is very effective at removing an aerosol from the gas stream; at a face velocity of 0.15 m s^{-1} the decontamination factor is over 1000 for particles larger than 2 micrometres, and is over 200 even for particles as small as 0.65 micrometres. Both solid and liquid aerosols are effectively removed from the gas stream. Solid particles remain trapped in the filter 14, which causes an increase in the pressure drop. This can be minimized by washing the filter medium by means of the spray nozzles 36, either continuously or at intervals.

Referring to Figure 3 there is shown graphically the variation in pressure drop, ΔP, across the filter candle 14 during fourteen successive filtration and washing cycles. The gas stream in this case contained a carbon black aerosol at a concentration of about 200 mg m^{-3}. As operation proceeds the filter candle 14 becomes loaded with trapped carbon black and the pressure drop ΔP increases. The aerosol flow is then stopped and the filter 14 is cleaned in situ as follows: first 40 litres of 0.01 weight percent detergent solution are sprayed through the spray nozzles 36; the filter 14 is left to drain for about 30 minutes; then 40 litres of demineralised water are sprayed through the spray nozzles 36 to rinse the filter 14; and the filter 14 is left to drain for about 45 minutes. The spray nozzles 36 are supplied with the cleaning liquid at a pressure of about 105 kPa. At this stage the filter 14 is clean but damp, and the pressure drop ΔP is typically about 2 kPa; a clean gas stream is then passed through the filter 14 for about 10 hours to dry it.

It will be seen from the graph that this cleaning and drying process restores the pressure drop after each cycle to near the initial value, and removes almost all the deposited carbon, which is carried away with the water draining from the filter 14 either down the duct 18 or into

the gutter 22 and so out of the U-tube 24 and outlet tube 26. During the drying stage no bubbling is observed at the outer surface of the filter 14, so no re-entrainment of the aerosol occurs. The use of detergent is advantageous, as is evident from the fact that in the one cleaning process marked A in which no detergent was used the pressure drop ΔP did not decrease to the usual extent.

It will be appreciated that there are other ways in which the candle filter 14 may be cleaned in situ. For example in a plant incorporating several filtration units 10 arranged in parallel to share the gas flow, the gas flow to one unit 10 may be stopped by blocking the side duct 20 while the filter 14 is washed, rinsed, and drained, but the side duct 20 may then be reopened so that the filter 14 is dried while filtering the gas stream. Yet again the filter 14 might be washed continuously by subjecting it to a gentle water spray while filtration proceeds, though this would lead to a greater pressure drop.

It will be understood that the filter medium might include layers of glass-fibre rather than stainless steel; that the drainage channels might be defined by means other than a coarse steel mesh; and that the candle filter 14 might be sealed to the housing 12 by means other than the gasket 60, for example it might fit over a tubular spigot with an O-ring seal (not shown). Yet again the filter itself might be rectangular in shape rather than tubular.

Claims

1. A filter for a gas stream comprising a plurality of layers of high voidage fibrous material whose fibres are of diameter less than 10 micrometres, and incorporating drainage channels defined between successive fibrous layers.

2. A filtration unit incorporating a filter as claimed in Claim 1, means to collect liquid draining from the filter, and spray means to spray a cleaning liquid over the filter.

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